soldered to a glass epoxy substrate, which is a circuit board, with utilization of an Sn-2.8Ag-15Bi-0.5Cu alloy solder. Soldering was carried out in a reflow furnace of a nitrogen environment at a peak temperature of 220°C. It was possible to obtain bonding portions having sufficient bonding strength. Similarly, a reflow soldering was carried out on a glass epoxy substrate in the air at 240°C with utilization of an Sn-2Ag-7.5Bi-0.5Cu alloy solder. Bonded portions produced by reflow heating have high reliability especially at a high temperature.

Example 2:

The cross-sectional structure of a TSOP lead is shown in Fig. 2 which is a part of the lead structure. A Cu layer 3 is formed on a lead 1 which is of an Fe-Ni alloy (42 alloy) and an Sn-Bi alloy layer 2 is formed on this Cu layer. The Sn-Bi alloy layer 3 and Sn-Bi layer 2 were formed by plating. The thickness of the Cu layer 3 was about 8 μm and that of the Sn-Bi plating layer was about 10 μm. The Bi content of Sn-Bi alloy plating layer was 5 wt%. Because of high rigidity of the TSOP lead, when it is used at a high temperature or under a condition that heat generation occurs in the device itself, stress generated at the interface is greater as compared with the QFP-LSI. In such cases, it is necessary to form an interface with sufficient bonding strength high enough

to withstand this interface stress and the Cu layer under the Sn-Bi layer is effective for this purpose.

The TSOP was soldered to a printed-circuit board in a vapor reflow furnace with utilization of an Sn-Ag-Bi alloy solder and the thermal cycle test was conducted. The test was conducted under the two test conditions: one hour per cycle of -55°C for 30 minutes and 125°C for 30 minutes, and one hour per cycle of 0°C for 30 minutes and 90°C for 30 minutes. After 500 cycles and 1,000 cycles the cross section was observed and the condition of formation of cracks was investigated. The cycle test result of crack occurrence was compared with a case where a TSOP of the same size having 42 alloy on which an Sn-10Pb alloy layer is directly formed, was soldered using a eutectic Sn-Pb alloy solder. Although cracks were formed early in the thermal cycles of -55°C/125°C, no problems arose with the thermal cycles of 0°C/90°C and a bonding interface which is adequate for practical use was obtained.

Example 3:

The electrode structures according to this invention can also be applied in an electrode on a board. For example, solder coating is effective in improving the solderability of boards. Conventionally, there have been used lead-containing solders such as a eutectic Sn-Pb alloy solder. Thus, the Sn-Bi alloy

layer according to the invention can be used to make the solder for coating lead-free. Furthermore, because the electrode of a board is made of copper, sufficient bonding strength can be obtained when an Sn-Ag-Bi alloy solder is used. An example in which this structure is applied is shown; an Sn-8Bi alloy layer of about 5 μm was formed by roller coating on a Cu pad (Cu electrode) on a glass epoxy substrate, which is a circuit board,

Wettability to boards and bonding strength were improved, because the solder layer was formed.

INDUSTRIAL APPLICABILITY

An electrode structure can be realized, which is suitable for an Sn-Ag-Bi alloy solder excellent as a lead-free material.

A bonded structure by a lead-free solder can be realized with utilization of a lead-free Sn-Ag-Bi alloy solder, in which an bonding interface which is stable and has sufficient bonding strength can be obtained.

An electronic article can be realized with utilization of a lead-free Sn-Ag-Bi alloy solder of low toxicity, which has a bonded structure by the lead-free solder, which can provide a stable bonding interface with respect to a change in process of time and a strength high enough to withstand stress generated in bonded portions by soldering due to a difference in thermal expansion coefficient between electric devices